One explanation for this is that the parts of the colonies that did not spawn in November may have spawned a month earlier in October.

Montipora turgescens and *M. grisea* (Family Acroporidae)

These species grow as an encrusting sheet on the reef bottom, and are covered in tiny pin size spikes and have tiny polyps that are difficult to see with the naked eye. Three small colonies of each species (six in total) were observed spawning on the fifth night after the full moon. *Montipora turgescens* spawned between 1945 and 2030 (1:25 to 2:10 after sunset). *M. grisea* spawned at 2045 (2:25 after sunset). Both species are hermaphroditic and released small pale brown egg-sperm bundles (approx. 1mm in diameter). Pigmented eggs in *Montipora* spp are often hard to detect prior to spawning because of the small size and pale colour of the egg-sperm bundles.

Merulina ampliata (Family Merulinidae)

Merulina ampliata forms thin sheets that grow in a roughly circular shape (up to 1m in diameter) close to the reef surface. This species is quite easy to identify as it has thin ridges with little bars that radiate from the centre of the coral out to the growing edge, and is usually green or pink in colour. Six large *M. ampliata* corals were observed spawning simultaneously on the reef slope at 1945 hrs (1:25 after sunset) on the fifth night after the full moon. At least two of these colonies spawned again on the sixth night. This species is hermaphroditic and released large (approx. 2mm diameter) pink egg-sperm bundles which could be seen setting for 10 minutes prior to their release.

Oxypora lacera (Family Pectinidae)

Oxypora lacera is similar in shape to *Merulina ampliata*, but is not found in shallow water (ie. shallower than 6 to 7m). The coral can be grey, pale brown or green, and is covered in small spiky dots that are usually a contrasting colour to the rest of the coral. *O. lacera* also spawned on the fifth and sixth night after the full moon. On the fifth night, a single colony spawned at 2030 hrs (2:10 after sunset). On the sixth night, five large individuals spawned between 2030 and 2130 hrs (2:10 to 3:10 after sunset). *Oxypora lacera* is hermaphroditic, and released strings of large (approx. 2mm diameter) yellow egg-sperm bundles. Egg-sperm bundles could be seen "setting" on the surface of the colony for approximately 30 minutes prior to release.

Lobophyllia hemprichii (Family Mussidae)

Lobophyllia hemprichii and other species belonging to the same family form medium sized dome or flat-dome shaped corals, with large very fleshy polyps. Six *L. hemprichii* corals spawned simultaneously on the reef slope at 1845 hrs (25 minutes after sunset) on the sixth night after the full moon. This species is dioecious, and each colony was seen to release several puffs of sperm from each polyp over a short period of approximately 10 mins.

Unidentified coral spawning

Many egg-sperm bundles were seen on the surface of the water on the reef flat at Fatumafuti on the 7th night after the full moon during the palolo rising. These bundles were small, pink in colour and were very numerous at approximately 0100 hrs. The parent corals producing these bundles were not identified.

Holothurian & palolo spawning observations

Stichopus chloronotus

The small, dark green holothurian (sea cucumber) *Stichopus chloronotus*, was observed spawning on the edge of the shallow lagoon on the third night after the full moon. *S. chloronotus* is dioecious (separate male and female). The majority of large individuals at the study site displayed spawning behaviour typical of most holothurians, with spawning individuals sitting upright on the substratum with the oral end waving in the water column. Thirty animals were observed releasing sperm or eggs, and several others were observed in spawning posture without releasing eggs or sperm. The majority of males spawned between 1830 and 1900 (10 to 40 minutes after sunset) while the females did not begin spawning until 1850 (50 minutes after sunset). Males intermittently released small continuous streams of sperm from the goniopore (reproductive opening), each lasting approximately 5 minutes. Spawning females were seen sitting upright for up to 20 minutes prior to releasing eggs. During this time the goniopore gradually swelled, forming a large obvious bump on the oral end. Eggs were subsequently released in a sudden and explosive puff, which could easily be mistaken for sperm as the eggs are opaque and very small (approx. 0.2 mm).

Palolo

Small numbers of palolo (*Eunice viridis*) were observed spawning in the shallow lagoon and reef slope at Faga'alu on third to sixth nights following the full moon. However the major spawning event was witnessed on the reef flat at Fatumafuti on the seventh night. Vast numbers of epitoke larvae appeared in a continual stream between the hours of 0100 and 0200. Especially thick patches of larvae appeared intermittently during this period.

DISCUSSION

Patterns of spawning of corals and other invertebrates in American Samoa

Preliminary observations confirm that a predictable mass coral spawning event takes place in American Samoa in the days before and including palolo spawning in the week after the full moon in late spring - early summer (Itano & Buckley 1988, this study). Direct observations confirm that this event includes at least 7 species of coral as well as several other invertebrates (Table 1). It is likely that the slicks known to occur before palolo rising in Samoan traditional lore are coral spawn slicks. Coral spawn slicks are very similar however, to slicks of *Trichodesmium* spp (an algae), which can occur throughout the year.

The time of coral spawning relative to the full moon and palolo spawning at Faga'alu in 1995 were consistent with the observations of coral spawning in American Samoa reported previously by Itano and Buckley (1988). Itano and Buckley observed several colonies of *Porites cylindrica* spawning 2 hours after sunset on the 3rd night after the full moon at Nu'uuli in 1988. In 1995 at Faga'alu, we also observed *P. cylindrica* spawning 2 hours after sunset on the 3rd night after the full moon (Table 1). Similarly, Itano and Buckley observed an encrusting *Montipora* spp spawning on the 4th and 5th nights after the full moon, approximately 2 hours after the full moon. We also observed two species of *Montipora* spawning 2 hours after sunset on the 5th night after the full moon (Table 1).

The close similarity between our observations and those of Itano and Buckley suggests that the timing of spawning of individual species in American Samoa is relatively predictable. It should be possible then, to organise coral spawning observations for interested Samoans in future years. We would recommend attempting to observe the large colonies of *Acropora* and *Porites* colonies spawn in the shallow lagoons at Faga'alu (this study) or Nu'uuli (Itano and Buckley 1998), as spawning in these corals is predictable and spawning occurs early in the evening. These sites are also relatively protected and the corals are in shallow water, thus coral spawning can be observed on snorkel and does not require SCUBA equipment.

Comparison of coral spawning between American Samoa and the Great Barrier Reef

The patterns of coral spawning at Faga'alu, in 1995 were also consistent with the patterns of coral spawning documented on the Great Barrier Reef (GBR). At Faga'alu, the timing of spawning relative to the full moon (number of days after the full moon) was consistent with observations of those species on the GBR (Table 1). The time of coral spawning relative to sunset at Faga'alu was also very close to the time after sunset that corals spawn on the GBR (Table 1). The spawning observations for *Stichopus chloronotus* at Faga'alu were also consistent with recent observations of this species on the Great Barrier Reef (Table 1).

The presence of egg-sperm bundles observed on the 7th night after the full moon at Fatumafuti in 1995, and similar observations by Itano and Buckley (1988) however, differs from patterns of spawning on the GBR. Although some coral species on the GBR are known to spawn on occasion on the 7th night after the full moon (Babcock et al. 1986), this does not usually result in the release of large numbers of egg-sperm bundles as observed at Fatumafuti. The majority of species on the GBR for which the spawning patterns are known spawn between the 2nd and 6th nights after the full moon. The species of corals that are spawning on the night of palolo rising in American Samoa are unknown.

	Faga'alu			Great Barrier Reef	
Species	Days before palolo	Day of spawning (days after full moon)	Hour of spawning (hours after sunset)	Day of spawning (days after full moon)	Hour of spawning (hours after sunset)
Porites cylindrica	4	3	2:15 (male only)	3, 4	1:40
Acropora formosa	3	4	3:00	4	1:40 - 2:45
Montipora turgescens	2	5	1:25 – 2:10	6	2:25
M. grisea	2	5	2:25	?	?
Merulina ampliata	1,2	5, 6	1:25	5, 6	1:30
Oxypora lacera	1,2	5, 6	2:10	6	1:30
Lobophyllia hemprichii	1	6	0:25	5	0:40
Stichopus chloronotus	4	3	0:10–3:00 (male) 0:30 (female)	2,3	3:00
Eunice viridis (palolo)	-	7	6:00 – 8:00	?	?

Table 1. Spawning observations at Faga'alu Bay, Tutuila, American Samoa between November 9 and November 12, 1995. The Full moon was on the 6th of November, and sunset was at approximately 1820. The palolo spawned on November 13. Times and dates of coral spawning on the Great barrier Reef taken from Babcock et al. (1986) and Babcock et al. (1994).

While this was the most detailed study of coral spawning conducted in American Samoa to date, it is by no means comprehensive. To obtain a more complete picture of the patterns of coral spawning in American Samoa it would be necessary to expand the study, to determine if corals are spawning at other times, and to include other species in other habitats. For example, some species from the Family Pocilloporidae and Poritidae release brooded planulae each month from late spring to late summer. While there are spawning records for approximately 150 coral species on the GBR (Harrison and Wallace 1990), there is also a large number of coral species (more than 100) for which there are no spawning observations. Two factors may affect the timing of coral spawning in late spring - early summer. When the ocean temperatures are warmer, or when the full moon falls at the beginning of the month, coral spawning on the GBR can occur a month earlier than normal, or may be split over two months. However, until a more detailed study can be undertaken, published reports from the Great Barrier Reef and the information contained in this report will provide a good estimate of the timing of mass coral spawning in American Samoa.

The importance of coral spawning in marine resource management

The period immediately before and after coral spawning is a critical period for the maintenance of healthy coral communities, and the recovery of damaged coral communities. Reproduction in corals is highly sensitive to stress (Harrison and Wallace 1990). Of particular, concern is the potential effect of a higher than normal input of sediment associated with changes in farming practice and intensity, and developments within the coastal zone. Although most corals have adaptations to remove sediment, the removal of an increasing amount of sediment because of coastal development and soil erosion requires significantly more energy. Thus less energy is available for reproduction, growth and repair of damaged tissue. Smothering of corals by sediment also disrupts feeding, decreases photosynthetic efficiency because of reduced light levels, and can result in partial or complete mortality of the coral.

The impact of sedimentation on the development and settlement of coral larvae in the weeks after coral spawning are also significant. The development of coral embryos through to competent planulae appears to be affected by water quality, with 77% fewer embryos developing normally in water from sediment stressed reefs (Richmond 1994). A layer of sediment on the reef surface can also prevent settlement of coral planulae, or restrict settlement of planulae to unsuitable microhabitats (Babcock and Davies 1991, Te 1992). Increased sedimentation may also reduce the survival rate of newly settled corals in the first few months after settlement (Sato 1985) due to smothering and abrasion. Therefore, in order to reduce the possible negative impacts of sediments on coral reproduction and spawning, it is advisable to minimise any activities that may increase the amount of sediment flowing into coastal waters, especially during the weeks leading up to and including coral spawning. Such activities should also be restricted in the month after coral spawning, to allow newly settled corals time to establish.

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